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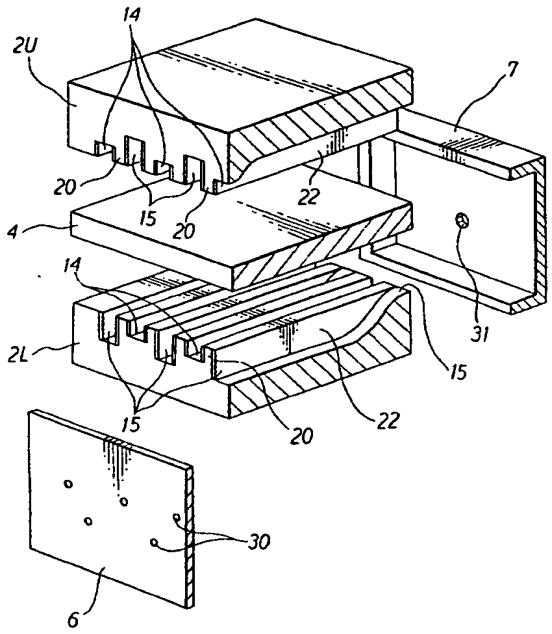
## (54) Ink jet head, ink jet recorder and method for manufacturing ink jet head

(57) An ink jet head has ink channels and blank channels alternately formed in a head body formed of a piezoelectric element. Then ink channels are formed inside the head body so as to communicate at one end thereof with nozzles and communicate at the other end thereof with a liquid supply port. The blank channels have the interior thereof blocked so as not to communicate with the liquid supply port. There is no need to use a shielding plate for sealing of blank channels in a conventional ink jet head. Thus, the number of constituent parts of the head can be reduced, and the reliability of sealing of blank channels can be increased. The blank channels are obtained by interrupting cutting with a cutter halfway.

Fig. 1

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## Description

The present invention relates to an ink jet head for ejecting ink through nozzles by exerting pressure on ink in ink channels formed in the ink jet head, and an ink jet recorder using the ink jet head, and a method for manufacturing the ink jet head.

A communication device such as a facsimile machine or an information processor such as a personal computer usually has a recorder capable of recording data, comprising characters or graphics, onto a sheet of paper so as to store this data as visual information. The recorder adopts a printing system such as impact system, thermal system or ink jet system. In recent years, increased attention has been paid to an ink jet recorder using the ink jet system which is highly quiet and can print on various types of paper.

The above-described ink jet recorder has an ink jet head with numerous nozzles for ejecting ink droplets toward a sheet of paper so as to print characters or graphics thereon. An ink jet head may have a structure as illustrated in Figs. 13 to 15. As shown there, a plate member 103 is bonded to an actuator base plate 100 to alternately form ejection channels (ink channels) 111, and dummy channels (blank channels) 110 which accommodate no ink and do not eject ink. A nozzle plate 107 having nozzles 106 formed in correspondence with the respective ejection channels 111 is bonded to an end face of the actuator base plate 100. A shielding plate 109 having channel holes 108 formed in correspondence with the ejection channels 111 is bonded to the other end face of the actuator base plate 100. As a result, the dummy channels 110 are spatially separated from an ink supply path 112, and the ink supply path 112 is caused to communicate only with the ejection channels 111. Side walls 101 between the ejection channels 111 and the dummy channels 110 are each constituted of a polarized piezoelectric material, and an electrode 102 is formed on the surface of each side wall. A drive electric field is applied to the side wall 101 via the electrode 102 to bend the side wall 101 and change the capacity of the ink chamber 110. The resulting increase and decrease in the ink pressure cause the ink to be discharged (ejected) from and supplied to the ejection channel 111.

According to this ink jet head, as noted above, the side walls 101 are bent to increase or decrease the capacity of the ejection channel 111 so that ink droplets will be ejected from a predetermined ejection channel 111. On this occasion, the adjacent dummy channel 110 increases or decreases in capacity. However, this dummy channel 110 is separated from the ink supply path 112 by the shielding plate 109 to be kept free from ink. Thus, the ink pressure in the adjacent ejection channel 111 is not affected by the capacity change of the dummy channel 110. Consequently, ink droplets can be ejected at the desired ink pressure.

The foregoing structure in which the dummy channels 110 and the ink supply path 112 are separated by the shielding plate 109, however, requires that the dummy channels 110 facing the ink supply path 112 be completely sealed with the shielding plate 109. This results in a large area of application of an adhesive for bonding the shielding plate 109. Thus, a bonding failure due to uneven application of the adhesive may occur, making it difficult to separate the dummy channels 110 from the ink supply path 112 reliably. Furthermore, the need for the shielding plate 109 increases the number of the parts required, thereby raising the cost of the ink jet head.

## SUMMARY OF THE INVENTION

It is an object of the present invention, therefore, to provide a liquid ejection head, an ink jet recorder, and an ink jet head manufacturing method, each of which can separate the dummy channels 110 from the ink supply path 112 reliably without using the shielding plate 109.

A first aspect of the present invention provides a liquid ejection head having a plurality of nozzles for ejecting a liquid and a liquid supply port through which the liquid is supplied, the liquid ejection head comprising:

a head body;
a plurality of liquid channels each formed inside the head body so as to communicate at one end thereof with the nozzle and communicate at the other end thereof with the liquid supply port, the liquid channels each being capable of ejecting the liquid through the nozzle when at least one of side walls of each liquid channel is deformed; and
a plurality of blank channels each formed inside the head body so as to be adjacent to the liquid channel via the side wall, the interior of the blank channel being blocked so that the blank channel and the liquid supply port will not communicate with each other.

According to the liquid ejection head of the present invention, there is no need to use the shielding plate employed in the ink jet head shown in Figs. 13 to 15, so that the number of the constituent parts of the head can be reduced. Moreover, the sealing of the blank channels, namely, dummy channels, can be achieved by the blockage of the blank channels. Thus, the reliability of sealing is enhanced compared with the adhesion of the shielding plate to the opening portions of the blank channels.

In the liquid ejection head of the present invention, the liquid channels may be formed so as to pass straight through the head body. Alternatively, when the liquid is fed through the liquid supply port provided in an upper part of the head, namely when the liquid is fed from a direction perpendicular to the lengthwise direction of the channel, as disclosed in the United States Patent No.

5,650,810, the liquid channel may be curved upwardly midway, without passing through the head body, to communicate with the liquid supply port. In the present invention, whichever structure the liquid channel has, the blank channels each have one end thereof blocked inside the head body.

The liquid ejection head of the present invention may further include a nozzle plate having the nozzles formed therein, a member having the liquid supply port formed therein, and a cover plate for covering channel opening portions open along the lengthwise direction of the liquid channels and the blank channels. In this case, the bottom of the blank channel comes into contact with the cover plate at or adjacent to one end of the blank channel, whereby the one end of the blank channel can be blocked inside the head body. The side wall may be constituted by laminating piezoelectric layers polarized in reverse directions.

The liquid ejection head of the present invention may be a liquid ejection head formed by a method including the steps of:

forming a plurality of channels parallel and at predetermined spacing in one direction of a plate material made of a piezoelectric material such that one of the adjacent channels is blocked at one end thereof to constitute a blank channel, while the other channel is open at both ends thereof to constitute a liquid channel, whereby the head body is produced;
securing the nozzle plate having nozzles formed therein to the head body so as to establish communication between the nozzles and one end of each of the liquid channels;
securing the member having a liquid supply port formed therein to the head body so as to establish communication between the liquid supply port and the other end of each of the liquid channels; and
securing the cover plate to the head body so that the plurality of liquid channels and blank channels formed in the head body are covered in the lengthwise direction.

A second aspect of the present invention provides an ink jet recorder comprising:

an ink jet head having a plurality of nozzles for ejecting ink onto a recording medium and an ink supply port through which ink is supplied, and;
an ink supply device connected to the ink jet head for supplying ink thereto;
the ink jet head including:
a head body;
a plurality of ink channels each formed inside the head body so as to communicate at one end thereof with the nozzle and communicate at the other end thereof with the ink supply port, the ink channels each being capable of ejecting ink through the nozzle when at least one of side walls of each ink channel is deformed; and
a plurality of blank channels each formed inside the head body so as to be adjacent to the ink channel via the side wall, the interior of each blank channel being blocked so that the blank channel and the ink supply port will not communicate with each other.

According to the ink jet recorder of the present invention, the constitution of the ink jet head is so simple that the recorder can be produced at a low cost. Furthermore, the blank channels of the ink jet head can be sealed without fail, so that the recorder can be a highly reliable product.

A third aspect of the present invention provides a method for producing an ink jet head having a plurality of ink channels and blank channels formed in a head body, the method comprising the steps of:

forming a plurality of channels parallel and at predetermined spacing in one direction of a plate material made of a piezoelectric material such that one of the adjacent channels is blocked at one end thereof to constitute a blank channel, while the other channel is open at both ends thereof to constitute an ink channel;
securing a nozzle plate having nozzles formed therein to the plate material so as to establish communication between the nozzles and one end of each of the ink channels;
securing a member having an ink supply port formed therein to the plate material so as to establish communication between the ink supply port and the other end of each of the ink channels; and
securing a cover plate to the plate material so that the plurality of ink channels and blank channels formed are covered in the lengthwise direction.

According to the method for producing an ink jet head of the present invention, when the plurality of ink channels and blank channels are to be formed using, say, a diamond cutter, the plate material is cut so that the resulting channels will completely cross (pass through) the head body if the channels serve as ink channels. To form a channel which will make up a blank channel, the plate material is cut, beginning at one end thereof, but its cutting is stopped before the cut area extends to the other end, whereby one of the ends of the channel is blocked. By so forming the blank channel, it becomes possible to block the blank channel without using a member such as a shielding plate. Thus, the procedure for the production of the ink jet head can be simplified.

In the above method of the present invention, blank channels and ink channels can be formed in another plate material made of a piezoelectric material by the step of forming a plurality of channels parallel and at predetermined spacing; and

the plate material and the other plate material can

be positioned such that the ink channels of the plate material and the ink channels of the other plate material are not opposed to each other, and the plate material and the other plate material can be bonded together via the cover plate such that lengthwise open portions of the ink channels of the plate material and the other plate material are covered with the cover plate.

The present invention will be more clearly understood from the following description, given by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is an exploded perspective view of an ink jet head according to an embodiment of the present invention;
Fig. 2 is a longitudinal sectional view of the ink jet head of Fig. 1;
Fig. 3 is an explanatory view showing the state of ink chambers in the ink jet head of Fig. 1;
Fig. 4 is an exploded perspective view of an ink jet head according to another embodiment of the present invention;
Fig. 5 is a longitudinal sectional view of the ink jet head of Fig. 4;
Fig. 6 is another longitudinal sectional view of the ink jet head of Fig. 4;
Fig. 7 is an exploded perspective view of an ink jet head according to still another embodiment of the present invention;
Fig. 8 is a longitudinal sectional view of the ink jet head of Fig. 7;
Fig. 9 is another longitudinal sectional view of the ink jet head of Fig. 7;
Fig. 10 is an exploded perspective view of an ink jet head according to a modified embodiment of the present invention;
Fig. 11 is a longitudinal sectional view of the ink jet head of Fig. 10;
Fig. 12 is another longitudinal sectional view of the ink jet head of Fig. 10;
Fig. 13 is an exploded perspective view of a conventional ink jet head;
Fig. 14 is a longitudinal sectional view of the ink jet head of Fig. 13; and
Fig. 15 is another longitudinal sectional view of the ink jet head of Fig. 13.

Embodiments of the present invention will now be described with reference to the accompanying Figs. 1 to 12.

An ink jet head related to the embodiment of the invention, as illustrated in Fig. 1, has a first actuator base plate 2U, a second actuator base plate 2L, a plate member 4, a nozzle plate 6, and a manifold member 7. Both actuator base plates 2U, 2L are each formed of a piezoelectric material comprising a lead zirconate titanate (PZT) based ceramic material. On one surface of each actuator base plate, a plurality of two kinds of channels, i.e., first and second channels 14 and 15, formed by cutting with a diamond blade or the like are alternately provided. As the piezoelectric material, a lead titanate (PT) based ceramic material may be used.

The first channel 14, as shown in Fig. 2, mostly has a flat upper (or bottom in 2L) surface 14a. This surface 14a is formed with a first depth H1 in a region ranging from the rear end (right end in the drawing) to an intermediate portion near the front end (left end in the drawing) of the first or second actuator base plate 2U or 2L. Then, the surface 14a is formed to become shallower from the intermediate portion toward the front end, and have a second depth H2 at the front end 14b. The second channel 15, like the first channel 14, mostly has a flat bottom (or upper in 2U) surface 15a. This surface 15a is formed with a depth H3 in a region ranging from the front end to a site near the rear end of the actuator base plate 2. Then, the surface 15a is formed to be coplanar, at the rear end 15b, with one surface (the surface on the open plane side in the longitudinal direction of each channel) of the first and second actuator base plates 2U and 2L. These first channels 14 and second channels 15, as shown in Fig. 1, are arranged alternately with side walls 20 therebetween.

The side wall 20, as illustrated in Fig. 3, is formed of a plurality of (e.g., two) layers of a piezoelectric material that have been laminated in the depth direction of the channel 14 or 15. The side wall 20 is polarized in a direction perpendicular to the direction of arrangement, and the longitudinal direction of, these channels 14 and 15, and the respective layers of the side wall 20 are polarized in reverse directions 27U, 27L to each other. On the wall surfaces of the side wall 20, electrodes 22 are formed by vacuum deposition or plating. The electrodes 22 apply an electric field in a direction perpendicular to the reverse directions 27U and 27L, thereby bending the polarized side wall 20 as shown in Fig.3.

The first and second actuator base plates 2U and 2L constituted as described above are disposed such that their first channels 14 are not opposed to each other, for example, that the first channel 14 is opposed to the second channel 15 as shown in Fig.3. Between the first and second actuator base plates 2U and 2L, the flat plate-shaped plate member 4 comprising a ceramic material or a resin material is provided. The plate member 4 is adhered to the aforementioned one surface of the actuator base plates 2U, 2L in a liquid-tight condition by means of an epoxy resin adhesive 24. Thus, the first channel 14 of the first and second actuator base plates 2U and 2L, as shown in Fig. 2, is covered with the plate member 4 to define an ejection channel 10 which serves as an ink (liquid) channel with its front end and rear end open. The second channel 15 is also covered with the plate member 4 to form a dummy (blank) channel 11 with its front end open and with its rear end 15b being sealed by the contact of the one surface of the actuator base plates 2U, 2L with the plate member 4.

To the front ends of the first and second actuator

base plates 2U and 2L having the ejection channels 10 and dummy channels 11 and the plate member 4, the nozzle plate 6 is bonded using the above-mentioned epoxy resin adhesive. The nozzle plate 6 is formed from a plastic material such as polyalkylene (e.g., polyethylene) terephthalate, polyimide, polyether imide, polyether ketone, polyether sulfone, polycarbonate or cellulose acetate.

In the nozzle plate 6, nozzles 30 are arranged in a staggered manner, as shown in Fig. 1, in agreement with the ejection channels 10 arranged alternately in two rows, i.e., upper and lower rows. The nozzle 30, as shown in Fig. 2, is in a nearly truncated conical shape. Its bore increases from the exit side toward the ejection channel 10 side, reaching nearly the maximum diameter that can be set for the channel cross section of the ejection channel 10, at the end face of the ejection channel 10. The ejection channel 10 which the nozzle 30 communicates with is desirably constituted as follows: The ratio of the second depth H2 of the ejection channel 10 at the end beside the nozzle 30 to the first depth H1 of the ejection channel 10 at a position distant from the nozzle 30, i.e. a position at which the bottom of the ejection channel 10 is plane, is set to be in the range of from 0.1 to 0.8. This is to ensure that air bubbles can be fully removed through the nozzle 30 by a decreased number of treatments for closely contacting a suction device with the outside of the nozzle 30 and sucking ink in the ejection channel 10 under negative pressure. Furthermore, the channel cross section beside the front end 14b of the ejection channel 10 is desirably constituted as follows: The ratio of the distance between the side walls 20 to the height of the side wall 20 is set to be in the range of from 0.5 to 2.0 so that the removal of air bubbles can be performed even more satisfactorily.

To the rear ends of the first and second actuator base plates 2U and 2L and the plate member 4, the manifold member 7 is bonded. In a part of the manifold member 7, an ink supply port 31 is formed for the supply of ink from an ink tank (not shown). The manifold member 7 forms an ink supply path 9 communicating with all of the ejection channels 10. When the ejection channel 10 increases in capacity, the manifold member 7 feeds ink to the expanded ejection channel 10.

In the foregoing constitution, the actions of the ink jet head will be described.

When the ink jet recorder is to perform printing, as shown in Fig. 3, a specific ejection channel is selected in accordance with print data given. For electrodes 22A and 22D of dummy channels 11A and 11C located on both sides of the selected ejection channel 10B, a drive voltage is produced. Also, electrodes 22B and 22C of the ejection channel 10B are grounded to have a GND potential. As a result, the respective layers of the polarized side walls 20A and 20B on both sides of the ejection channel 10B deform in reverse directions because of a piezoelectric thickness shear effect, so that the side walls 20A and 20B bend so as to widen outward at the center. Since the ejection channel 10B increases in capacity owing to the bending of the side walls 20A, 20B, the ink pressure in the ejection channel 10B decreases. Thus, ink in the ink supply path 9 is fed into the ejection channel 10B. Then, the drive voltage for the electrodes 22A and 22D is removed with a predetermined timing with respect to the supplied ink in the ejection channel 10B, whereupon the side walls 20A, 20B return to their original straight form. By this return action, the ink in the ejection channel 10B is pressurized at a high pressure, whereby an ink droplet is ejected from the nozzle 30.

Alternatively, an ink droplet may be ejected by bending the side walls 20A, 20B so as to approach each other, and ink may be supplied from the ink supply path 9 into the ejection channel 10B by restoring the side plates 20A, 20B to the straight form. It is also permissible to combine these bending actions in a plurality of ways, thereby stabilizing the ejection of ink droplets or varying the operating characteristics of ink droplets.

The above manner of printing varies the capacity of the dummy channels 11A, 11C, because the side walls 20A, 20B are shared between the ejection channel 10B and the dummy channels 11A, 11C adjacent to the ejection channel 10B. On this occasion, the dummy channels 11A, 11C, as shown in Fig. 2, have the rear end thereof sealed by the contact of one surface of the actuator base plate 2L with the plate member 4. Thus, the dummy channel is separated spatially from the ink supply path 9 and no ink is present there. When the capacity of the dummy channels 11A, 11C changes, therefore, this change in capacity does not affect the ink pressure of the ejection channel 10B via the ink supply path 9. Hence, printing is carried out with ink droplets in a stable amount of ejection. Preferably, the sealed portion at the rear end of the dummy channel is not very large.

As described above, the ink jet head according to the instant embodiment is constituted such that a plurality of channels are formed in the first and second actuator base plates 2U, 2L; of these plural channels, the channels constituting ink channels for ejection of ink are the ejection channels 10; the channels adjacent to the ejection channels via the side walls 20 are the dummy channels 11 which do not accommodate ink; and at the rear end (one end) of the first and second actuator base plates 2U, 2L, the ink supply path 9 is connected for opening the same-side end of the plurality of ejection channels 10 and supplying ink to the plurality of ejection channels 10, whereby the dummy channel 11 does not reach the rear end (one end).

In this manner, the sealing of the dummy channel 11 relative to the ink supply path 9 is completed. Compared with the conventional sealing of the dummy channels relative to the ink supply path 9 by a shielding plate, therefore, this type of sealing lessens the adhering procedure for sealing, thereby increasing the reliability of sealing. Since the shielding plate for sealing is not necessary, moreover, the number of the parts for forming the dummy channels can be reduced.

In the instant embodiment, the side walls 20 are polarized in a direction perpendicular to the direction of arrangement of, and the longitudinal direction of, the plurality of channels 10, 11, and a voltage is applied to the electrodes 22 provided along the side wall 20, whereby the adjacent ejection channel 10 and the adjacent dummy channels 11 can be deformed so that their capacities will be changed. The application of voltage to the electrodes 22 thus deforms the adjacent ejection channel and dummy channels in directions in which their capacities are varied. However, ink is absent in the dummy channels 11 sealed with respect to the ink supply path 9. Thus, ink can be ejected from the predetermined ejection channel, with no influence exerted on the other ejection channels 10.

In the instant embodiment, the ejection channels 10 and the dummy channels 11 are alternately arranged, and both side walls 20 of the ejection channel are deformable. Thus, when both side walls 20 of a specific ejection channel are deformed, a great change in capacity is caused to the predetermined ejection channel with the other ejection channels being unaffected, since the ejection channels and the dummy channels are alternately arranged. Consequently, ink can be ejected efficiently.

In the instant embodiment, the plate member 4 is bonded to the first and second actuator base plates 2U and 2L so as to cover the open surface (one surface) in the longitudinal direction of the first channels 14 and second channels 15 corresponding to the plurality of channels. When the plate member 4 is bonded to the first and second actuator base plates 2U and 2L, the vicinity of one end 15b of the second channel 15 contacts the plate member 4, thus reliably sealing the dummy channel 11 relative to the ink supply path 9.

In the instant embodiment, a pair of first and second actuator base plates 2U and 2L alternately having the ejection channels 10 and dummy channels 11 are arranged such that the ejection channels 10 of the first actuator base plate 2U are opposed to the dummy channels 11 of the second actuator base plate 2L, and the plate member 4 is bonded to and disposed between the pair of first and second actuator base plates 2U and 2L so as to cover the open surface in the longitudinal direction of each channel. Since the ejection channels 10 are so alternately arranged in two rows, upper row and lower row, by both actuator base plates 2U and 2L, high density recording becomes possible. When the pair of first and second actuator base plates 2U and 2L are bonded together via the plate member 4, the vicinity of one end of each of the dummy channels 11 of the actuator base plates 2U and 2L contacts either surface of the plate member 4, so that the dummy channels 11 can be reliably sealed relative to the ink supply path 9.

The ink jet head according to the instant embodiment has the first and second actuator base plates 2U and 2L bonded together via the plate member 4, thus having channels comprising the ejection channels 10 and dummy channels 11 in two rows, upper row and lower row. However, the ink jet head is not restricted to this constitution. That is, the ink jet head, as shown in Figs. 4 to 6, may be constituted such that a plate member 4 is bonded to one surface of one actuator base plate 2 via an adhesive layer 24, whereby channels comprising ejection channels 10 and dummy channels 11 are provided in one row. In this case, the side wall 20 is formed of one layer of a piezoelectric material polarized in only one direction, and an electrode 22 is formed only in an upper half of the side wall 20.

The ink jet head, as shown in Figs. 7 to 9, may also be constituted as follows: To an actuator base plate 2 polarized in a direction 27L, a piezoelectric member 25 polarized in the direction 27U opposite to the direction 27L is bonded via an adhesive layer 26. Then, the piezoelectric member 25 and the actuator base plate 2 are cut to form first channels 14 and second channels 15. Electrodes 22L and 22U are formed on a side wall 20 comprising the piezoelectric member 25 and the actuator base plate 2 to give the side wall 20 two layers polarized in reverse directions 27U and 27L. As noted from this, the ink jet head is configured to comprise a plurality of layers polarized in reverse directions, a plurality of channels formed along the plurality of layers, and the plate member 4 bonded to the actuator base plate 2 so as to cover the open surface in the longitudinal direction of the plurality of channels. According to this configuration, when voltage is applied to the electrodes 22L, 22U, the plurality of layers deform in reverse directions in the same manner as in Fig. 3. This causes a marked change in capacity to the ejection channel, whereby ink can be ejected efficiently.

The ink jet head, as shown in Figs. 10 to 12, may also be constituted as follows: First and second actuator base plates 2U, 2L having electrodes 22U, 22L formed on side walls 20U, 20L of first channels 14U, 14L and second channels 15U, 15L are vertically bonded together as a pair. As a result, ejection channels 10 and dummy channels 11 are defined by the side walls 20U, 20L polarized in one direction 27U and in another direction 27L. In this manner, the pair of first and second actuator base plates 2U, 2L having a plurality of channels are bonded together so that the open surfaces in the longitudinal direction of the channels of the base plates 2U, 2L are opposed to the others. This brings the vicinity of one end 15b of the second channel 15 of the dummy channels into contact with the vicinity of the counterpart. Thus, the dummy channel 11 can be reliably sealed with respect to the ink supply path 9.

The ink jet head of the present invention that has been described is useful for an ink jet recorder such as ink jet printer and facsimile. The ink jet printer usually has the ink jet head, an ink supply device such as an ink cartridge for feeding ink to the ink jet head, and a carriage for holding the ink jet head and moving it along and over a recording medium such as printing paper. Thereby, the ink jet printer ejects the ink from the ink jet

head onto a certain printing place on the recording medium. An example of the ink jet printer to which the present invention can be applied is disclosed in the United States Patent No. 5,639,220, the disclosure of which is incorporated herein by reference.

According to the above-described embodiments, the rear end of the dummy channel is not cut, but left intact for use as a sealed portion. However, the rear end of the dummy channel may be cut similar to the ejection channel, and a filler may be filled into the rear end portion of the dummy channel to form a sealed portion.

The present invention has been described with an ink jet head for use in an ink jet printer being taken as the example. However, the invention may be applied to not only ink jet printer, but any types of recorder such as a facsimile using an inkjet head. Also, the invention is not restricted thereto, and may be applied, for example, to any types of apparatus for ejecting molten solder, or a decorative liquid for foods and cosmetics.

## Claims

1. A liquid ejection head having a plurality of nozzles for ejecting a liquid and a liquid supply port through which the liquid may be supplied, the liquid ejection head comprising:

   a head body;
   a plurality of liquid channels each formed inside the head body so as to communicate at one end thereof with one of the nozzles and communicate at the other end thereof with the liquid supply port, each liquid channel being capable of ejecting the liquid through the one of the nozzles when at least one of side walls of the liquid channel is deformed; and
   a plurality of blank channels each formed inside the head body so as to be adjacent to the liquid channel via the side wall, the interior of each blank channel being blocked so that the blank channel and the liquid supply port will not communicate with each other.

2. The liquid ejection head as claimed in claim 1, wherein the liquid channel is formed so as to pass straight through the head body, while the blank channel has one end thereof blocked inside the head body.

3. The liquid ejection head as claimed in claim 1 or 2, wherein the side wall is formed of a piezoelectric element.

4. The liquid ejection head as claimed in claim 3, which has an electrode formed on the side wall, and wherein the side wall is polarized in a direction perpendicular to the direction of arrangement of, and the longitudinal direction of, the plurality of channels, such that a voltage may be applied to the electrode to deform the liquid channel.

5. The liquid ejection head as claimed in any preceding claim, wherein the liquid channels and the blank channels are arranged alternatively.

6. The liquid ejection head as claimed in any preceding claim, wherein the side wall is constituted by laminating piezoelectric layers polarized in reverse directions.

7. The liquid ejection head as claimed in any preceding claim, wherein the head body has a set of head members each having a plurality of liquid channels, and the head members are bonded together such that their respective liquid channels are opposed to each other.

8. The liquid ejection head as claimed in any one of claims 1 to 6, wherein the head body has a set of head members each having a plurality of liquid channels, the head members are positioned such that their respective liquid channels are not opposed to each other, and the head members are bonded together via a cover plate which covers lengthwise open portions of their respective liquid channels.

9. The liquid ejection head as claimed in any preceding claim, further including a nozzle plate having the nozzles formed therein, a member having the liquid supply port formed therein, and a cover plate for covering channel opening portions open along the lengthwise direction of the liquid channels and the blank channels.

10. The liquid ejection head as claimed in claim 9, wherein the bottom of the blank channel comes into contact with the cover plate, whereby one end of the blank channel is blocked inside the head body.

11. The liquid ejection head as claimed in any one of claims 1 to 8, further including a nozzle plate having the nozzles formed therein, and a cover plate for covering channel opening portions open along the lengthwise direction of the liquid channels and the blank channels, the cover plate having the liquid supply port formed therein.

12. The liquid ejection head as claimed in claim 9 or 10, which has been formed by a method including the steps of:

    forming a plurality of channels parallel and at predetermined spacing in one direction of a plate material made of a piezoelectric material

such that one of the adjacent channels is blocked at one end thereof to constitute a blank channel, while the other channel is open at both ends thereof to constitute a liquid channel, whereby a head body is produced;
securing the nozzle plate having nozzles formed therein to the head body so as to establish communication between the nozzles and one end of each of the liquid channels;
securing the member having a liquid supply port formed therein to the head body so as to establish communication between the liquid supply port and the other end of each of the liquid channels; and
securing the cover plate to the head body so that the plurality of liquid channels and blank channels formed in the head body are covered in the lengthwise direction.

**13.** An ink jet recorder comprising:

an ink jet head comprising a liquid ejection head according to any preceding claim; and
an ink supply device connected to the ink jet head for supplying ink thereto; wherein
the nozzles are for ejecting ink onto a recording medium and the liquid supply port is an ink supply port through which ink is supplied.

**14.** The ink jet recorder as claimed in claim 13 including an ink jet head which has been formed by a method including the steps of:

forming a plurality of channels parallel and at predetermined spacing in one direction of a plate material made of a piezoelectric material such that one of the adjacent channels is blocked at one end thereof to constitute a blank channel, while the other channel is open at both ends thereof to constitute an ink channel, whereby a head body is formed;
securing the nozzle plate having nozzles formed therein to the plate material so as to establish communication between the nozzle and one end of each ink channel;
securing the member having an ink supply port formed therein to the plate material so as to establish communication between the ink supply port and the other end of each ink channel; and
securing the cover plate to the plate material so that the plurality of ink channels and blank channels formed are covered in the lengthwise direction.

**15.** A method for producing an ink jet head having a plurality of ink channels and blank channels formed in a head body, the method comprising the steps of:

forming a plurality of channels parallel and at predetermined spacing in one direction of a plate material made of a piezoelectric material such that one of the adjacent channels is blocked at one end thereof to constitute a blank channel, while the other channel is open at both ends thereof to constitute an ink channel;
securing a nozzle plate having nozzles formed therein to the plate material so as to establish communication between the nozzle and one end of each ink channel;
securing a member having an ink supply port formed therein to the plate material so as to establish communication between the ink supply port and the other end of each ink channel; and
securing a cover plate to the plate material such that the plurality of ink channels and blank channels formed are covered in the lengthwise direction.

**16.** The method as claimed in claim 15 wherein the plurality of ink channels and blank channels are formed using a cutter.

**17.** The method as claimed in claim 15 or 16 wherin blank channels and ink channels are formed in another plate material made of a piezoelectric material by the step of forming a plurality of channels parallel and at predetermined spacing; and

the plate material and the other plate material are positioned such that their respective ink channels are not opposed to each other, and the plate material and the other plate material are bonded together via the cover plate such that lengthwise open portions of their respective ink channels are covered with the cover plate.

Fig. 1

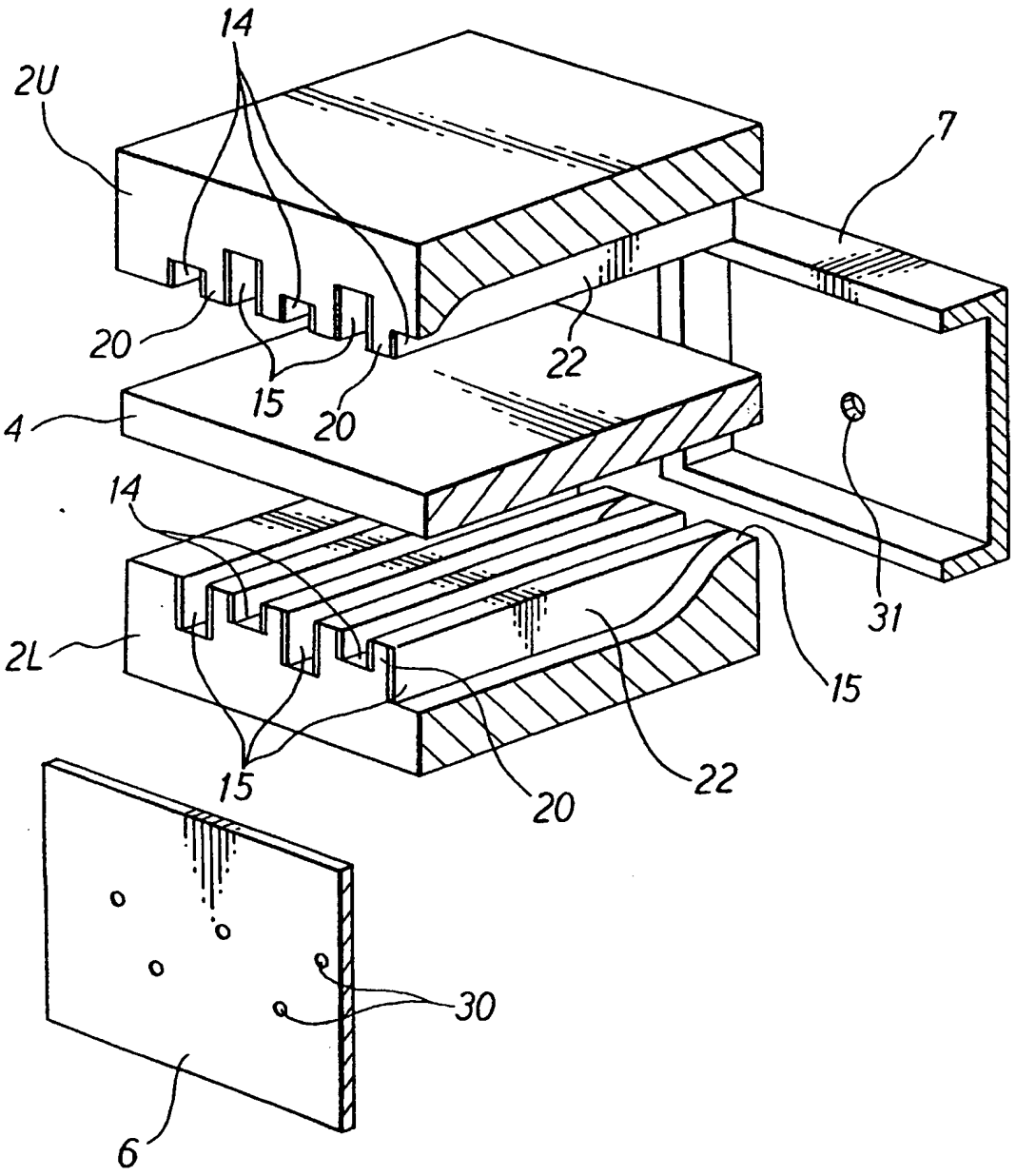


Fig. 2

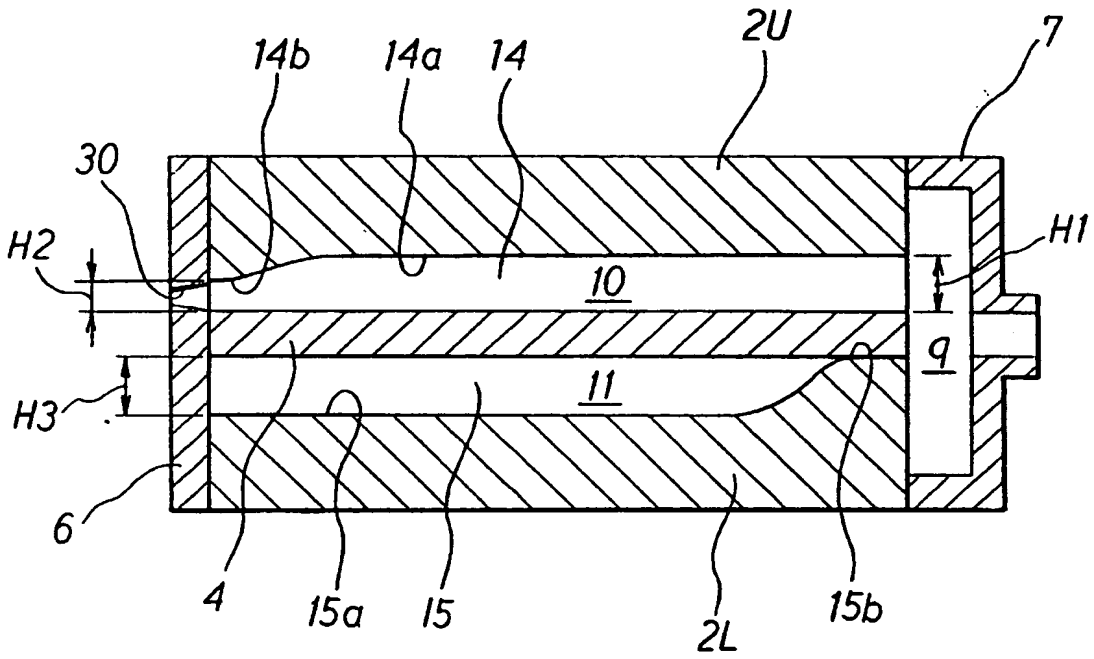


Fig. 3

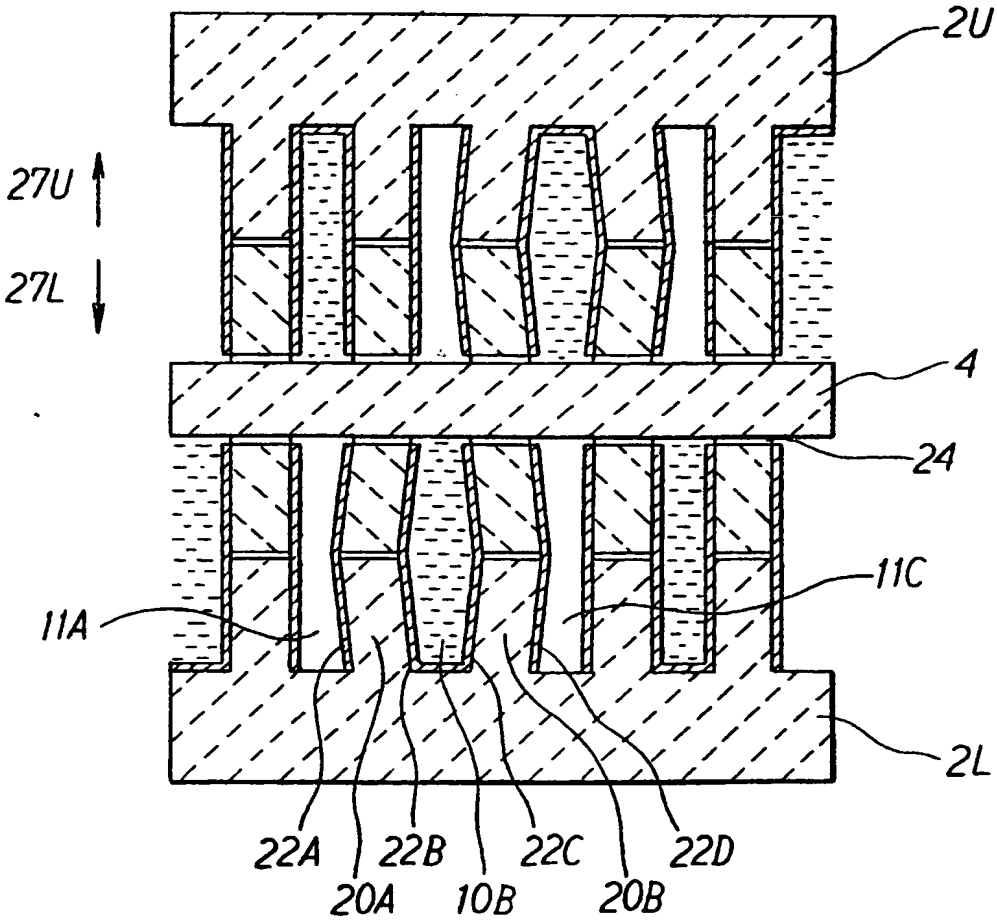


Fig. 4

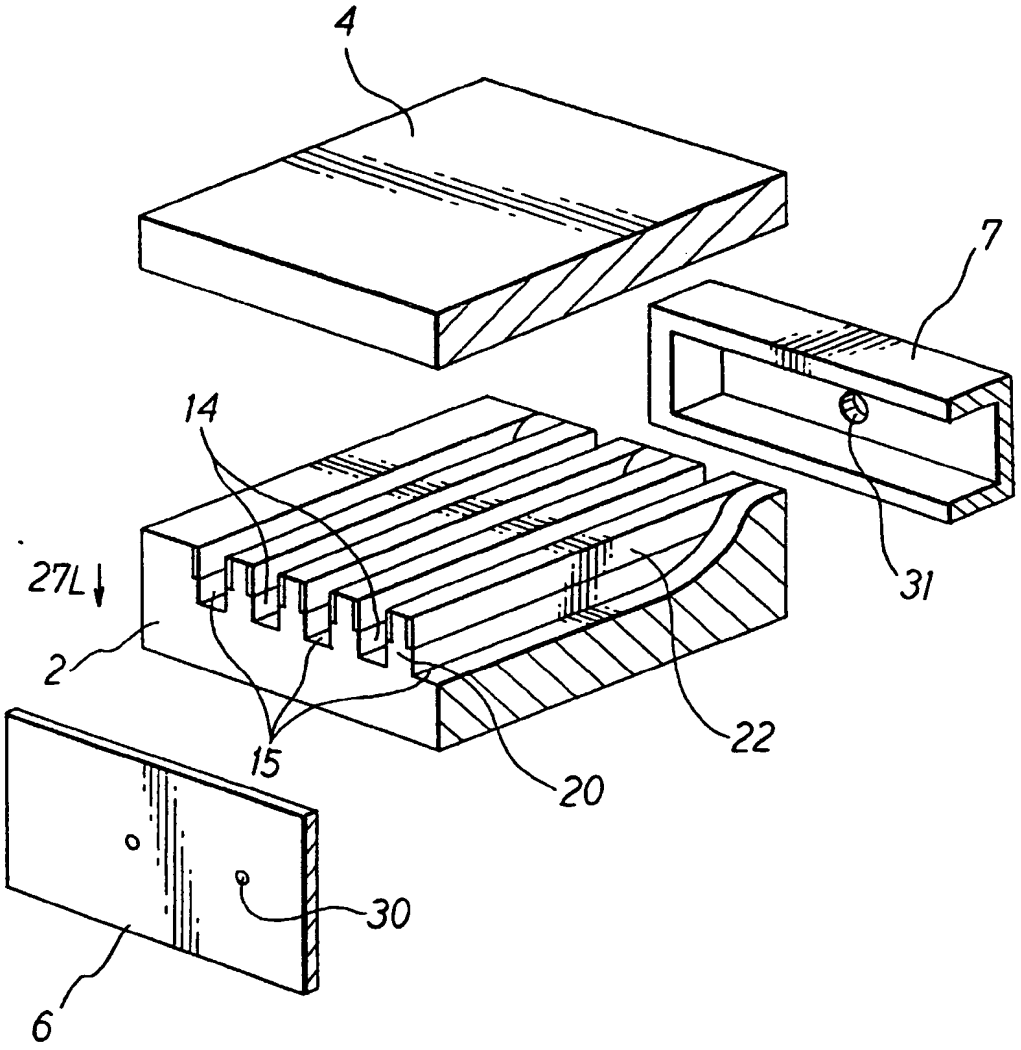


Fig. 5

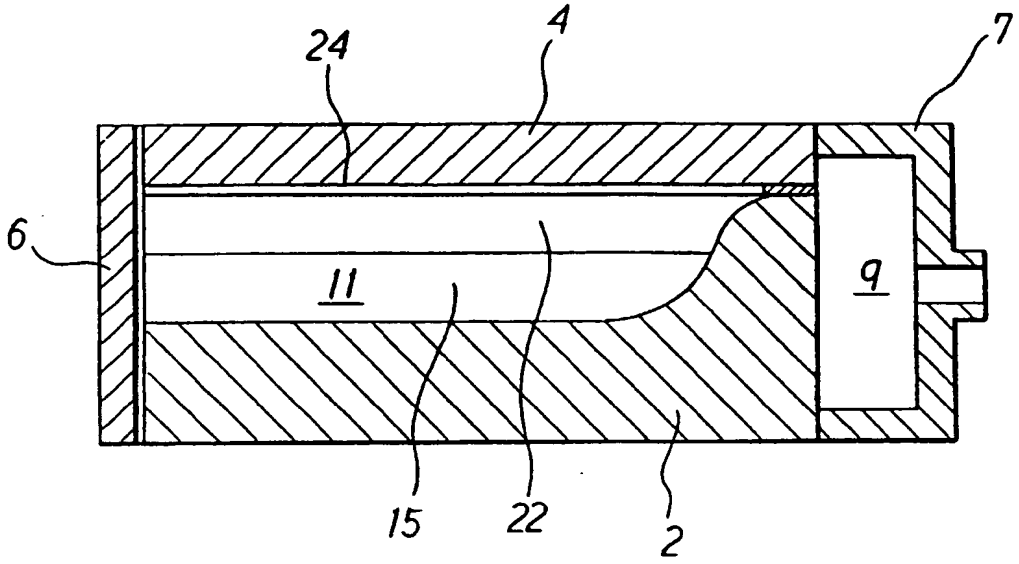



Fig. 6

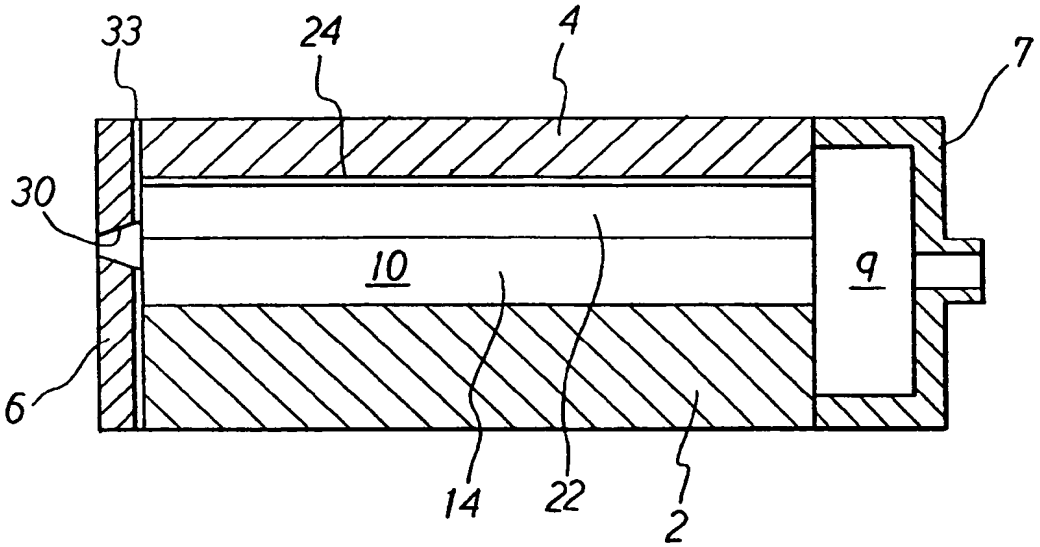


Fig. 7

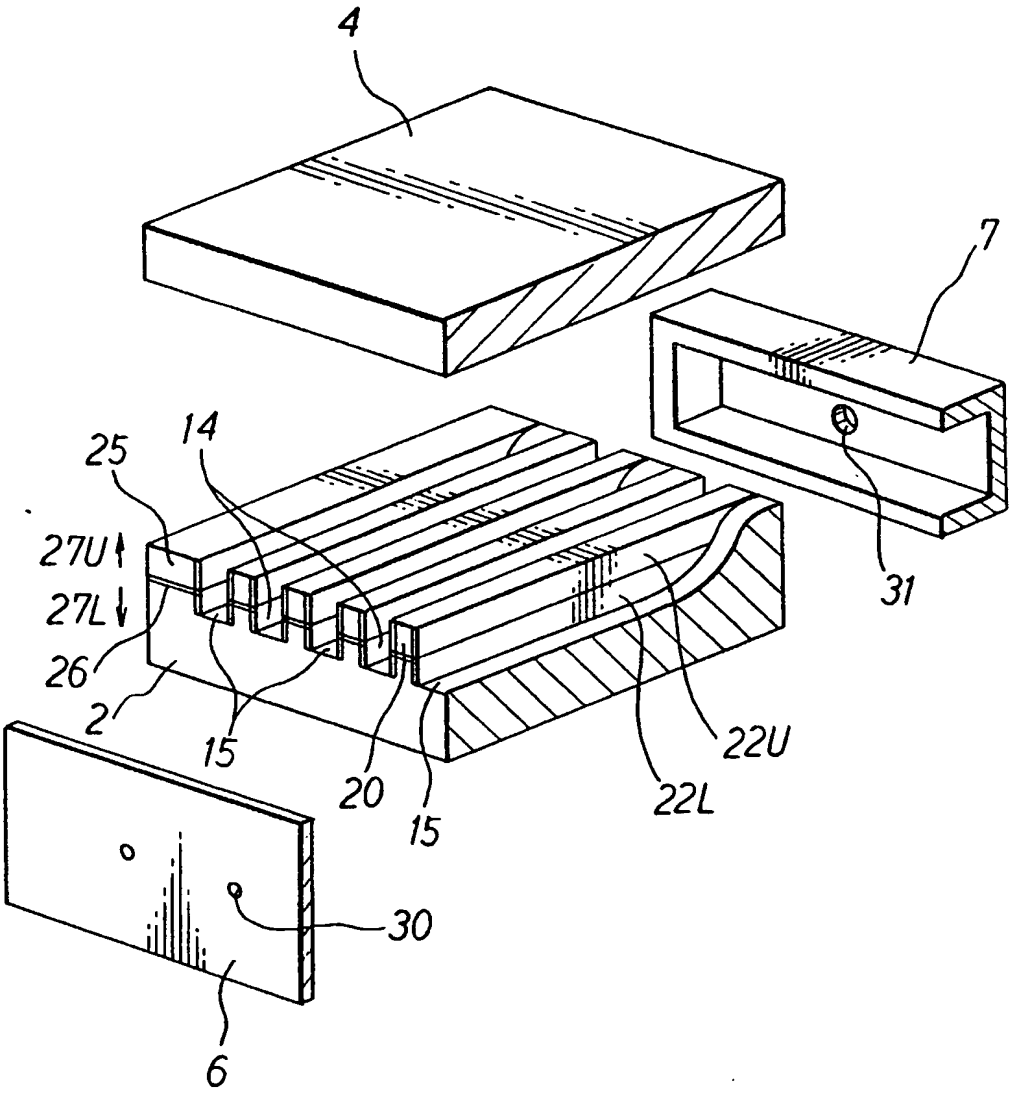


Fig. 8

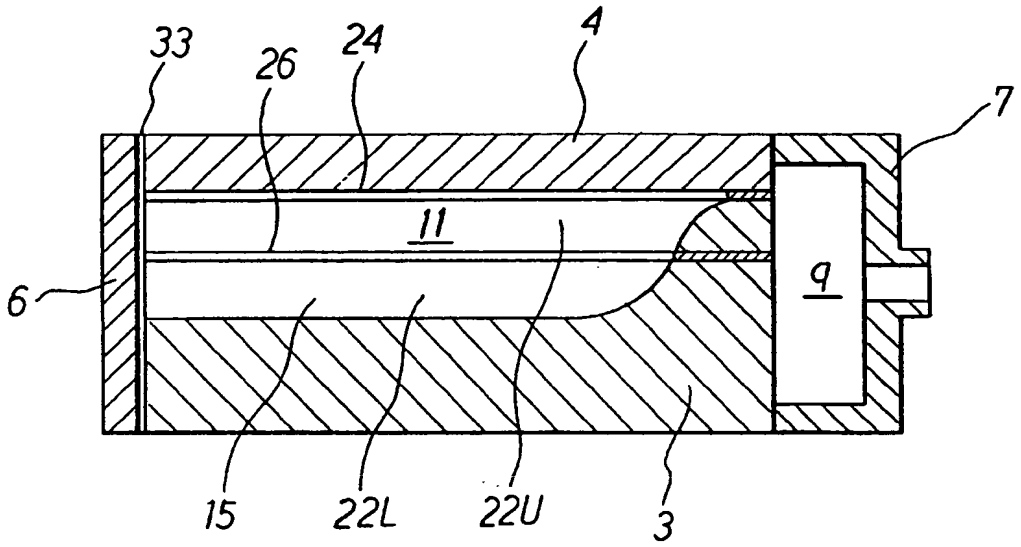



Fig. 9

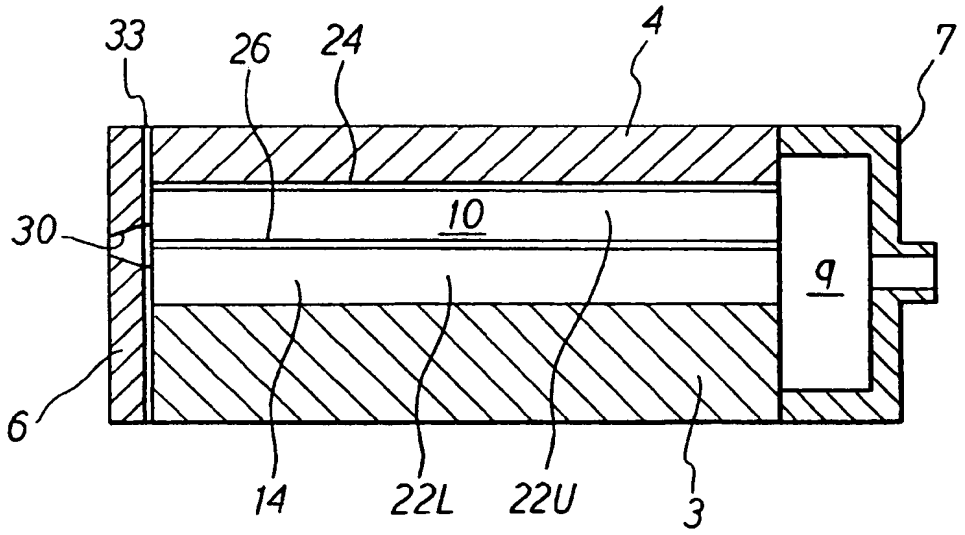


Fig. 10

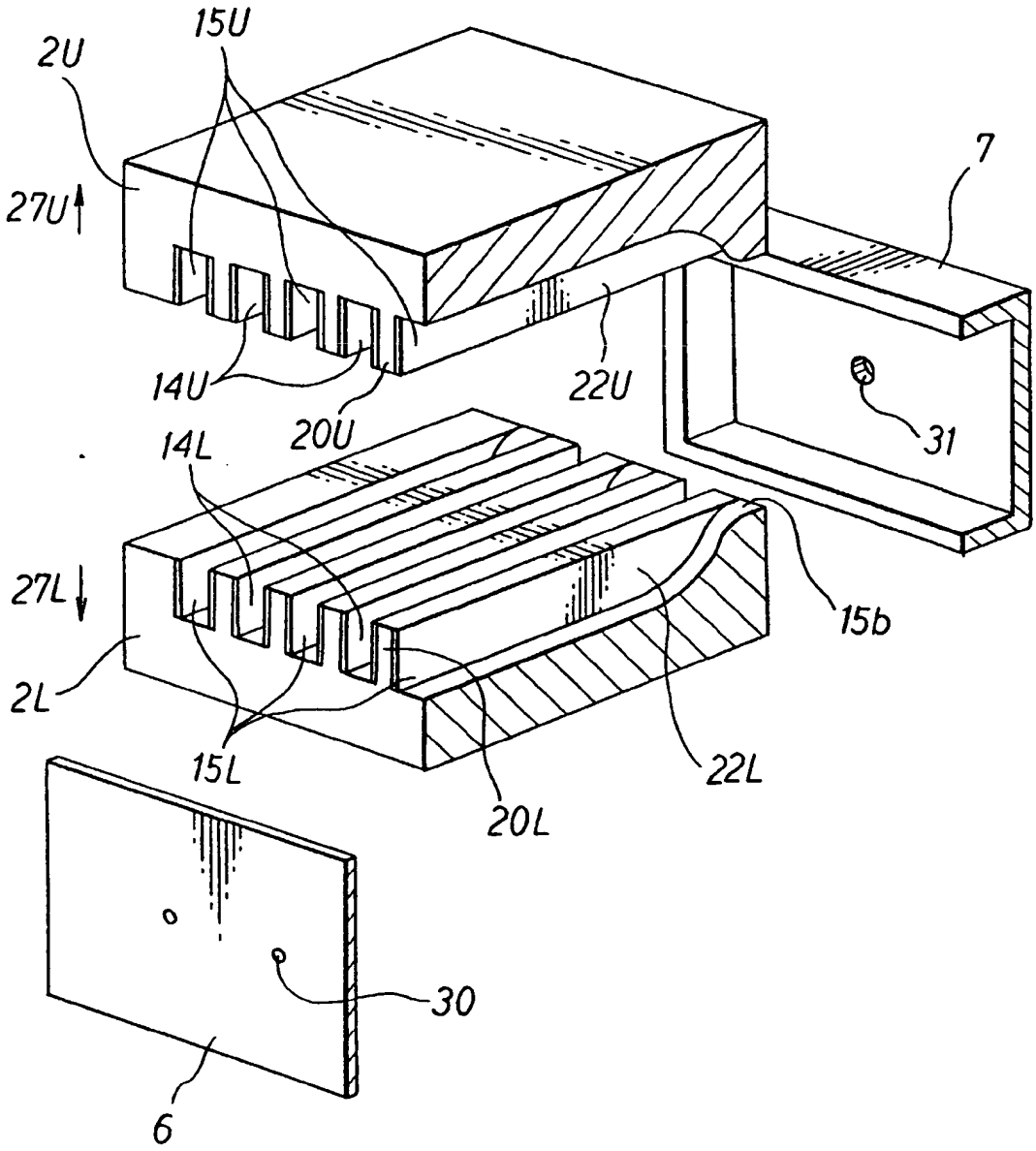


Fig. 11

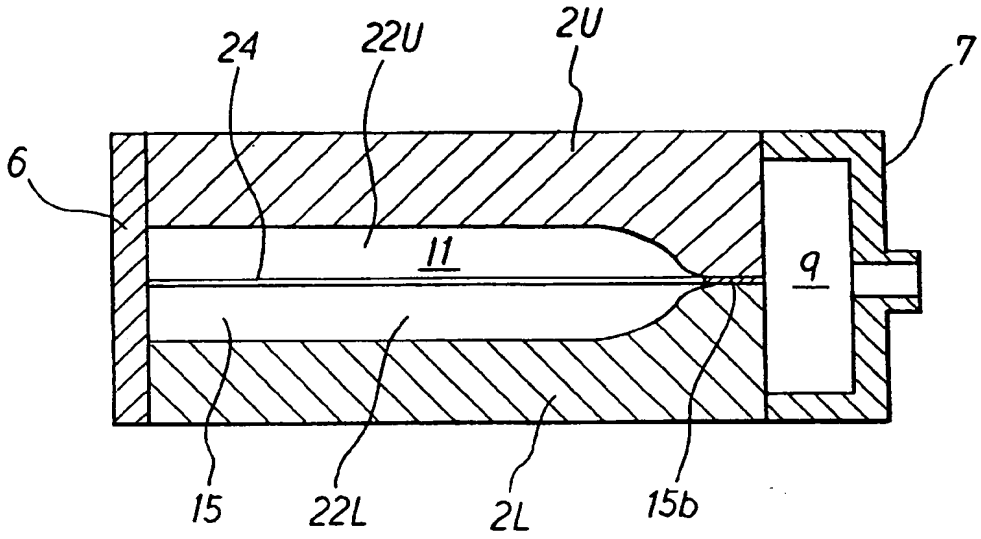



Fig. 12

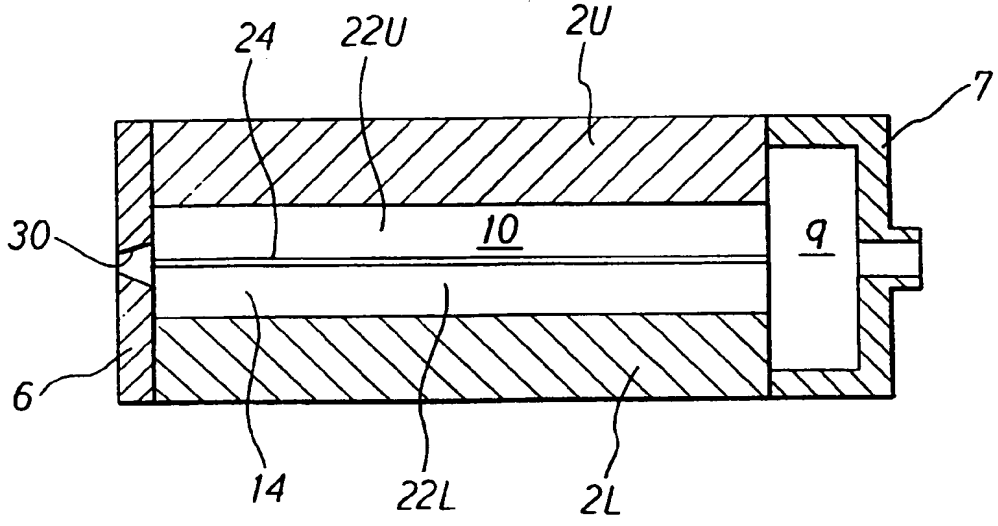


Fig. 13

PRIOR ART

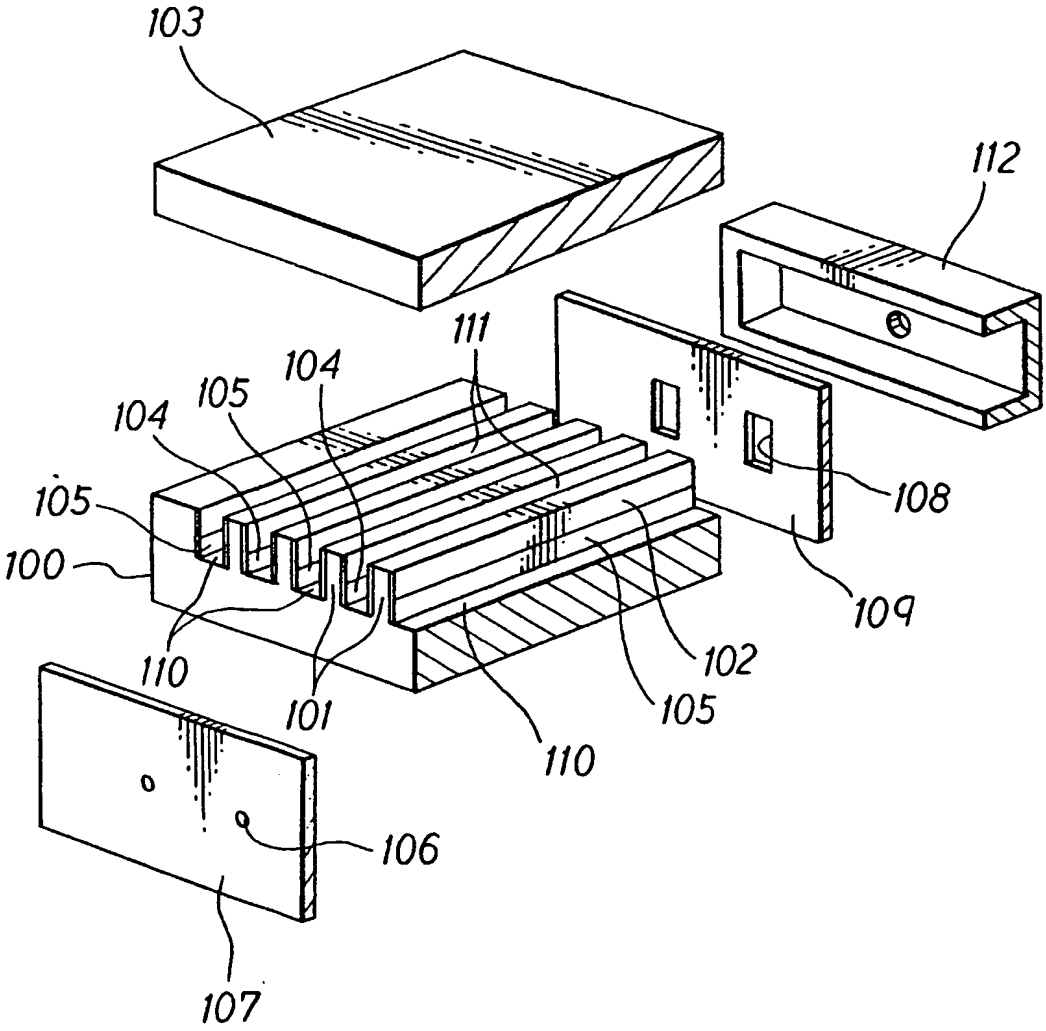


Fig. 14

PRIOR ART

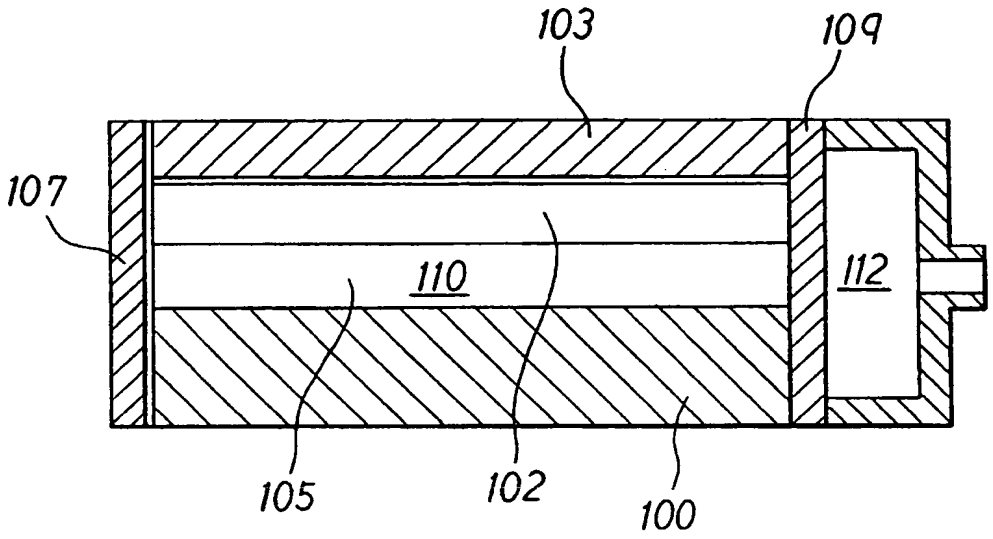
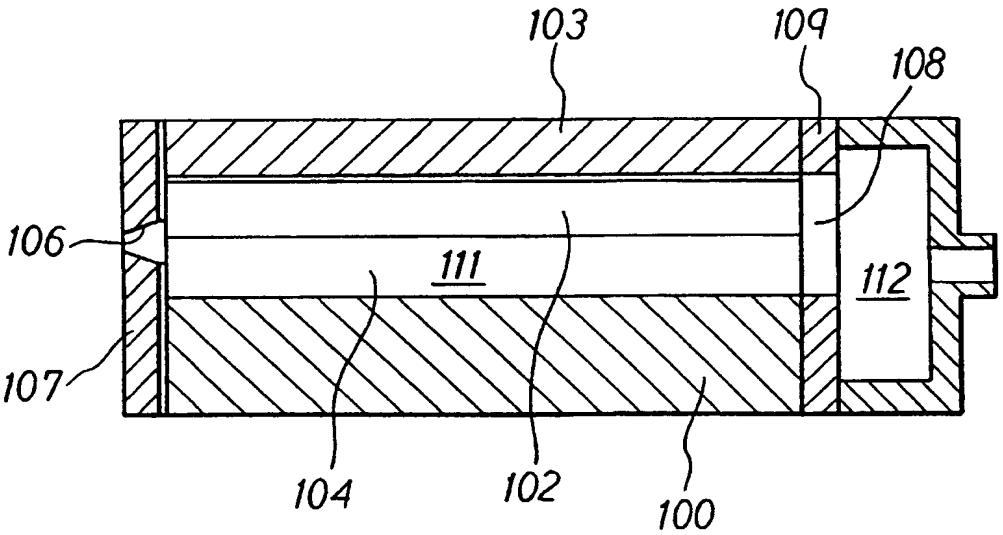



Fig. 15

PRIOR ART



European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 98 30 2461

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| X | EP 0 595 654 A (CITIZEN WATCH CO LTD) 4 May 1994<br>* column 12, line 19 - line 20; figures 9,32 * | 1-6,13, 14 | B41J2/045<br>B41J2/14 |
| X | US 5 432 540 A (HIRAISHI HISATO) 11 July 1995<br>* column 7, line 55 - column 9, line 55; figures 10-15 * | 1-6,13, 14 | |
| X | * figure 15 * | 7 | |
| X | JP 08 187 846 A (BROTHER IND LTD) 23 July 1996<br>* the whole document *<br>-& US 5 686 946 A (MIZUTANI TSUYOSHI) 11 November 1997<br>* column 5, line 39 - line 41 * | 1,3-5, 8-17 | |
| X | EP 0 653 303 A (BROTHER IND LTD) 17 May 1995<br>* the whole document * | 1,3-5, 9-11 | |
| X | JP 07 132 596 A (BROTHER IND LTD) 23 May 1995<br>* figures 1-10 *<br>-& US 5 625 393 A (ASAI HIROKI) 29 April 1997<br>* column 5, line 32 - line 36 * | 1 | TECHNICAL FIELDS SEARCHED (Int.Cl.6)<br>B41J |
| X | EP 0 707 962 A (BROTHER IND LTD) 24 April 1996<br>* the whole document * | 1 | |
| X | JP 08 197 728 A (BROTHER IND LTD) 6 August 1996<br>* the whole document *<br>-& US 5 680 163 A (SUGAHARA HIROTO) 21 October 1997 | 1 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 22 June 1998 | Van Oorschot, J |

CATEGORY OF CITED DOCUMENTS

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